File D 50.1/7 McCOOK FIELD REPORT, SERIAL No. 1924

AIR SERVICE INFORMATION CIRCULAR

(AVIATION)

PUBLISHED BY THE CHIEF OF AIR SERVICE, WASHINGTON, D. C.

Vol. IV August 15, 1922 No. 363

HEAT TREATING BATH COMPOSED OF SODIUM CHLORIDE, SODIUM CARBONATE, AND SODIUM CYANIDE

(MATERIAL SECTION REPORT No. 166)

▽

Prepared by E. V. Schaal
Engineering Division, Air Service
McCook Field, Dayton, Ohio
May 17, 1922

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

CERTIFICATE: By direction of the Secretary of War the matter contained herein is published as administrative information and is required for the proper transaction of the public business.

HEAT TREATING BATH COMPOSED OF SODIUM CHLORIDE, SODIUM CARBONATE, AND SODIUM CYANIDE.

PURPOSE.

To determine the suitability of a heat-treating bath composed of sodium chloride and sodium carbonate with and without addition of sodium cyanide.

CONCLUSIONS.

A mixture of 40 per cent sodium chloride and 60 per cent sodium carbonate is found to decarburize the steel considerably, but this decarburizing tendency is neutralized by the addition of about 15 per cent of sodium cyanide.

Caution must be exercised in heating the mixture for the first time to avoid "cave-ins" followed by expulsion of the mixture, due to sudden evolution of steam when the unmolten portions fall into the hot liquid.

There is considerable foaming and flaming on the surface of the bath after adding the cyanide, but this phenomenon subsides after the bath has been held in the vicinity of 1,400° F. for six or eight hours.

A bath consisting of 35 per cent NaCl, 52 per cent Na_2CO_3, and 13 per cent NaCN gave satisfactory results for heat-treating parts where sealing must be reduced to a minimum and where the temperature used ranges between 1,200° and 1,600° F.

MATERIAL.

120 lbs. sodium carbonate (commercial).
80 lbs. sodium chloride (commercial).
20 lbs. sodium cyanide (commercial).
2 rods about 6 inches long of 1045 steel.
2 rods about 6 inches long of drill steel (hypereutectoid).

PROCEDURE.

The furnace used for this investigation is one formerly used as a lead pot. The pot, which is made of cast iron, is about 20 inches in diameter and 16 or 18 inches in depth.

In order to melt the sodium carbonate and chloride they were mixed in the proportion of 40 parts of chloride to 60 parts of carbonate (anhydrous) and the pot was filled, when cold, with this mixture. The furnace was then fired. It was soon observed that when any of the unfused material fell into the molten part there was a sudden evolution of steam and mixture from the pot. On one occasion so much unfused material caved in that an explosion resulted in which fully half of the contents of the pot, molten and otherwise, were expelled over a radius of about 10 feet. After this experience, only small amounts were added at a time until enough of the molten material was obtained. After having been once melted, no trouble was experienced in remelting.

Before adding the cyanide, one specimen of 1045 steel was treated at 1,600° F. for one hour and one of drill steel was treated at 1,425° F. for one hour, both treatments being followed by water quenching. The 1045 steel was represented as 1020 steel, which accounts for the high temperature used in treating it.

The surface condition of these specimens was noted after the treatment, and transverse sections were prepared in the usual manner for microscopic examination. Photomicrographs were taken of these sections, as shown in Figures 1, 3, and 5.

A record was kept of the amount of carbonate and chloride used in making up the original bath, but inasmuch as part of what had been weighed was lost by the explosion, an estimate had to be made of the quantity remaining in order to compute the 15 per cent of cyanide which was to be added. This was done as carefully as possible, but it leaves some doubt as to the exact proportions actually used. This is thought to be of no great importance, however, as long as the proportions are within 2 or 3 per cent of those desired.

The cyanide was added when the bath was frozen and the furnace was slowly brought up to the melting temperature (about 1,200° F.). By heating slowly, the moisture contained in the cyanide eggs was driven off without violence and resultant damage. As soon as the mixture was melted, after adding the cyanide, it began to evolve an inflammable gas which burned on the surface with a characteristic sodium flame color. This color of the flame need not be directly attributed to the gas that was burning, since the evolution of the gas caused fine particles of the sodium salts to be thrown into the air in a sort of mist in in which the gas burned. A rough chemical analysis made on powder deposited on articles in the vicinity of the furnace during this period showed that it contained chloride and carbonate of sodium.

Continued heating above 1,400° F. for seven or eight hours caused the evolution of gas to stop, and after that, the other two steel specimens were treated for one hour each in the same manner as the first ones had been treated. After surface examination they were also sectioned and prepared for microscopic examination. Photomicrographs, Figures 2, 4, and 6, were taken of these specimens.

The temperature of the bath was determined by means of a chromel-alumel thermocouple incased in a chromel tube, and connected to a permanently installed recording potentiometer.

A sort of slag occurred on the surface of the bath after the cyanide was added, but this stopped forming in the course of 10 or 12 hours' heating. This slag was easily removed.

RESULTS.

SURFACE CONDITION OF SPECIMENS.

Specimen No. 1, which consisted of a plain carbon hypereutectoid steel, after having been held in the bath without cyanide for one hour at 1,425° F. and water quenched, had a uniform light-gray appearance except at a few places which were slightly mottled with a darker shade.

Specimen No. 3 (1045 steel), which was held for one hour at 1,600° F. in the same bath as specimen No. 1 and water quenched, had a dark-gray coating over it which could be chipped off by pounding with a hammer. The surface of the steel beneath the coating was bright and smooth.

Specimen No. 2 (plain carbon, hypereutectoid), which was held in the bath (after adding cyanide) for one hour at 1,425° F. and water quenched, possessed a smooth mottled surface similar to that ordinarily obtained from cyanide hardening.

Specimen No. 4 (1045 steel), which was held at 1,600° F. for one hour in the same bath as specimen No. 2 and water quenched, had the same surface appearance as the latter—that is, smooth and mottled.

METALLOGRAPHIC EXAMINATION.

The four specimens were examined in the quenched condition and photomicrographs were taken of each in the center and at the edge. Of these only two are shown (Figs. 5 and 6). In order to more carefully study the surface effects of the heat-treating bath, sections cut from each of the same specimens were all sealed in a heat-treating box to prevent scaling, and heated to 1,500°, followed by cooling in the furnace. These sections were then mounted and polished and the photomicrographs of Figures 1, 2, 3, and 4 were taken at the edges to show the surface effects. A description of these potomicrographs follows:

Fig. No.	Spec. No.	Mag.	Remarks.
1	1	100	Without cyanide. Decarburized to 0.006 inch depth. Drill steel.
2	2	100	With cyanide. Very slight decarburization; about 0.002 inch depth. Drill steel.
3	3	100	Without cyanide. Decarburized to 0.006 inch depth. 1045 steel
4	4	100	With cyanide. Very slight carburization on surface. 1045 steel.
5	3	500	1045 steel, water quenched from 1,600°. Troosto-martensitic structure (troostite dark).
6	2	500	Drill steel, water quenched from 1,425°. Spheroidized cementite in martensitic matrix.

DISCUSSION OF RESULTS.

The relatively long period through which the specimens were held in the bath (one hour) is about five to ten times as long as would be required during actual heat-treating practice. Reducing the time of immersion will proportionately reduce the depth of surface effect from the bath. With this consideration, the effect of the bath with 15 per cent cyanide upon the two grades of steel used in this investigation would be negligible and far below that of any ordinary method of treatment. The surface of the treated part is such that for many purposes, such as tools, the finishing could be done before treatment, barring, of course, cases where warpage might make final machining necessary after treatment.

The fact that the 0.45 carbon steel was slightly carburized on the surface by the bath after cyanide was added, while the high carbon steel was slightly decarburized in the same bath, suggests that the carburizing action would be nil on a steel of intermediate carbon content (0.80 to 0.90 per cent). For any particular grade of steel a cyanide content in the bath could no doubt be arrived at, which would have a neutral effect upon the carbon of the steel.

The slag which rose to the top of the bath after the addition of cyanide may be due to attack of the mixture upon the cast-iron pot or upon some traces of lead still remaining in the pot from its previous use as a lead pot. Since the formation of slag appeared to cease completely, no attempt was made to discover its exact identity.

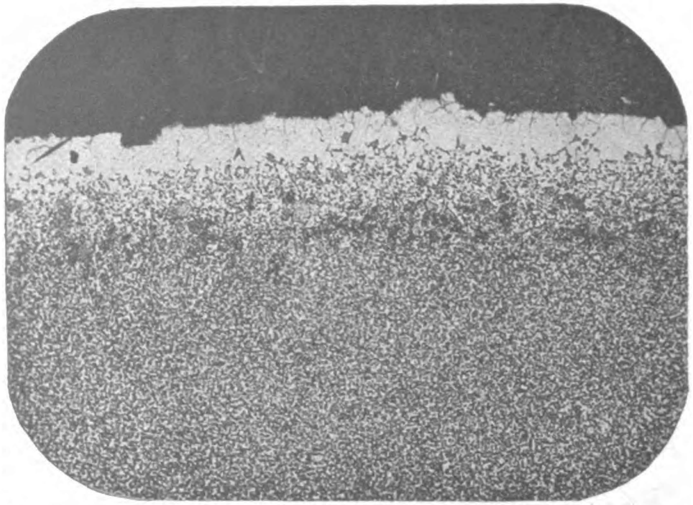

FIG. 677-1.—Magnification, 100 diameters. Etching, nitro-picric acid. Remarks: Specimen No. 1. Hyper-eutectoid steel; held one hour at 1425° F. in bath without cyanide; then furnace cooled from 1500° F. Decarburized edge at top of photograph.

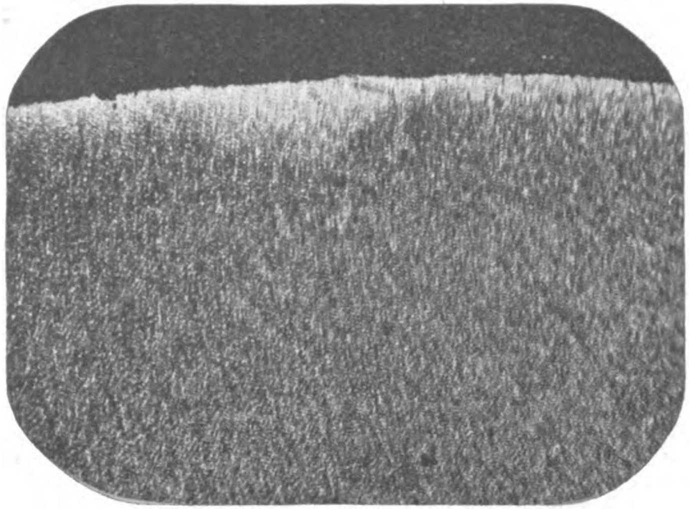

FIG. 677-2.—Magnification, 100 diameters. Etching, nitro-picric acid. Remarks: Specimen No. 2. Hyper-eutectoid steel; held one hour at 1425° F. in bath with cyanide; then furnace cooled from 1500° F. Edge (top) only slightly decarburized.

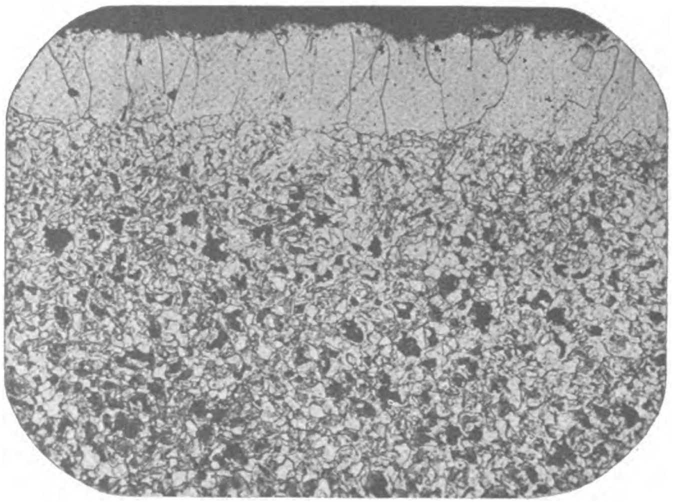

FIG. 677-3.—Magnification, 100 diameters. Etching, nitro-picric acid. Remarks: Specimen No. 3. 1045 steel; held one hour at 1600°F. in bath without cyanide, then furnace cooled from 1500° F. Decarburized edge at top of photograph.

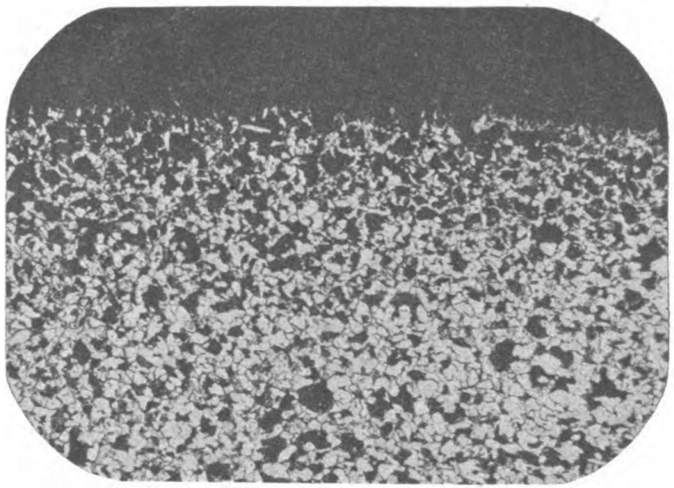

FIG. 677-4.—Magnification, 100 diameters. Etching, nitro-picric acid. Remarks: Specimen No. 4. 1045 steel; held one hour at 1600° F. in bath with cyanide: then furnace cooled from 1500° F. Edge of specimen (top) slightly carburized.

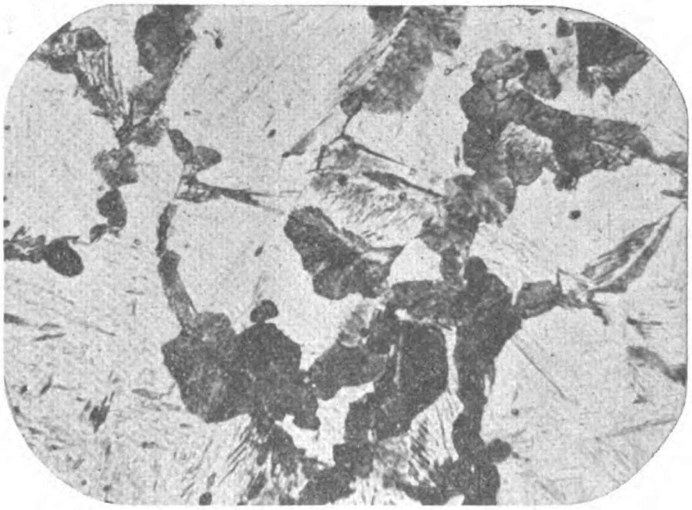

FIG. 677-5.—Magnification, 500 diameters. Etching, nitro-picric acid. Remarks: Specimen No. 3. 1045 steel after quench from 1600° F. Troosto-martensitic structure.

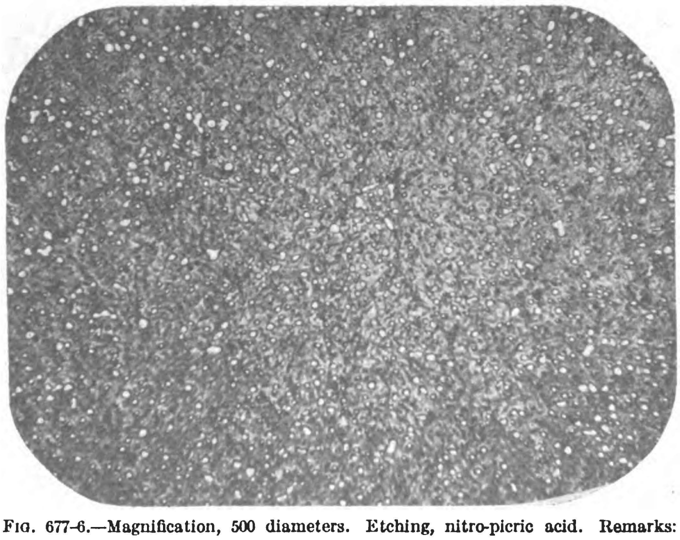

FIG. 677-6.—Magnification, 500 diameters. Etching, nitro-picric acid. Remarks: Specimen No. 2 after quench from 1425° F. Martensitic matrix with pro-eutectoid cementite spheroidized (white).